

THE SOLID IMAGE WEB VIEWER: A NEW WAY FOR 3D SURVEY DATA WEB-FRUITION

E. Agosto^(*), I. Picco^(**), F. Rinaudo^(*)

^(*) DITAG, Politecnico di Torino, 10129 Torino, Italy - eros.agosto@polito.it - fulvio.rinaudo@polito.it

^(**) GIS specialist, Torino, Italy- ivano.picco@gmail.com

Commission VI, WG VI/4

KEY WORDS: Spatial Information Sciences, Surveying, Internet/Web, Analysis, Consulting, Archiving, Three-dimensional

ABSTRACT:

3D information creation and fruition has always been, and still is, problematic. The creation of the 3D knowledge of objects has however become easier over the years: the combined use of LIDAR and the photogrammetric technique is at present one of the most diffused ways of reaching this goal.

Although the creation phase is fast and highly automated, the exploitation and the fruition of the data content is problematic, despite the chances offered by modern computer devices and software. 3D information in fact, involves the way man can use it. The representation of complete 3D information has to deal with the problem of using 2D supports where geographical information has been represented for many years. Even when the most powerful mean of world-wide communication, the internet, is used, 3D information has to be managed utilizing 2D video screens; the internet causes another problem, connected to the limited data-transfer capability of communication networks and the high amount of detailed 3D information data involved: as a result, only low and medium scale 3D models can be accessed on the internet, considering the need of simplifying the models.

The *solid image*, a tool that has been recently conceived by the Geomatics research group of the Land, Environment and Geo-Engineering Department, DITAG at the Politecnico di Torino, combines a user friendly interface with a light data structure and the completeness of 3D information. The utility of this tool was greatly appreciated by the users during its testing, therefore the Politecnico di Torino set up SIR – Innovative Survey Resources – a spin-off company in January 2006 with the aim of producing and marketing *solid image* based services.

At present the *solid image* can only be used in a desktop environment utilizing a common commercial software such as Adobe Photoshop, with a freely distributed plug-in, or a specific viewer, but it also seems to be suitable for easy access to a complete and accurate 3D model over the internet.

This article deals with the improvements that have been made in the web visualization prototype tool that is based on an Open Source architecture (Agosto, 2006); the viewer has been completely replanned, in order to offer a user-friendly fruition thanks to Ajax technologies in order to speed the navigation up. The tests were made on a *solid image* of the “S. Lorenzo” Royal Church in Turin, a baroque building designed by Guarini to host the Holy Shroud before it was moved into the Guarini Chapel in the Royal Palace.

1. INTRODUCTION

3D information creation and fruition has always been, and still is, problematic. The creation of the 3D knowledge of objects has however become easier over the years: the combined use of LIDAR and the photogrammetric technique is at present one of the most diffused ways of reaching this goal.

Although the creation phase is fast and highly automated, the exploitation and the fruition of the data content is problematic, despite the chances offered by modern computer devices and software. 3D information in fact, involves the way man can use it. The representation of complete 3D information has to deal with the problem of using 2D supports where geographical information has been represented for many years, and today is still represented.

2D supports have made it necessary to look for and find ways of “hiding” one dimension, in order to have the control of metric information: perspective and ortho – projection are examples of such a process; even now, in the computer age, the visualization of what it is a complete 3D model involves the use

of a 2D video screen, as 3D visualization devices expensive, and not fully diffused.

In order to develop a tool to communicate 3D information, it is necessary to first decide which infrastructure has to be used. In order to reach the largest number of potential users, regardless of their physical location, the tool has to be web-oriented.

The use of the internet involves another problem in 3D information consultation, connected with the limited data-transfer capability of communication networks and the large amount of detailed 3D information data involved: only low and medium scale 3D models can therefore be accessed on the internet, because of the need of simplifying the models.

Considering the fact that 2D supports are easy to use and that even modern computer science and 3D models that can be generated, can be used using 2D screens, with a successions of views of the 3D model, the DITAG - Land, Environment and Geo-Engineering Department - Geomatics research group at the Politecnico di Torino has developed a new survey tool called *solid image*.

1.1 Solid image

Solid image is a tool that can be used to analyse and present survey data, which allows the user to access and manage 3D data by simply viewing a 2D monoscopic image. It adds correct 3D metric information to simple photographs, in such a way that those users who are not experts in surveying can easily gain access to the information. In this way the photographic image becomes the view of an object on the 3D model.

It turns the philosophy of orthophotos upside down; using the same data, it reprojects the DDSM instead of the photographic image. The result of this procedure is a normal 2D photo, without any decay due to a resampling process, each point of which has 3D coordinates.

Solid image has led the way to a series of new products in the field of architectural and land surveying applications, making it possible to:

- Determine the position of any point of a digital image in a 3D reference system in real time, using a common PC;
- carry out correct three-dimensional measurements (lines, areas, volumes, angles, ...), by just selecting points on the image;
- return vector elements of interest, in order to spread the fruition and analysis of data to researchers who are not experts in the geomatric field, thus freeing them from the intermediation of a skilled photogrammetric operator ;
- integrate the information given by an original high quality colour image with the 3D geometry of each point represented in the photo.

1.2 Desktop usage of the solid image

The DITAG Geomatics research group at the Politecnico di Torino has developed a specific software called LSR2004® to create this product. The *Solid Image* and its tools can be used with LSRViewer® or common commercial software such as Adobe Photoshop®, using a freely distributed plug-in.



Figure 1. LSRViewer: A *Solid Image* and its measurement tools

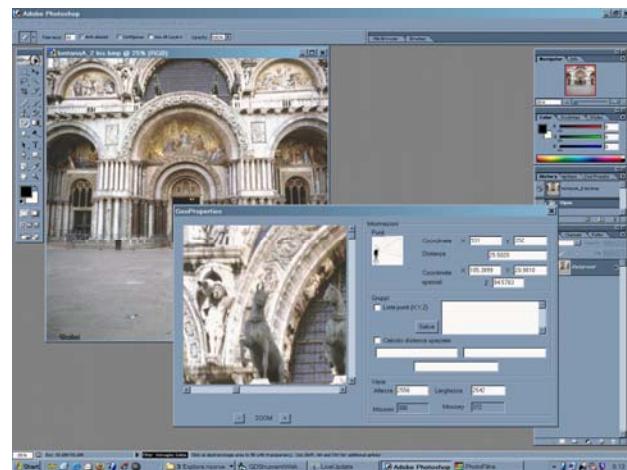


Figure 2. Fruition of a *Solid Image* using the plug-in

2. 3D INFORMATION ON THE INTERNET

Internet is the communication infrastructure that offers the best chance to reach people and places. It enhances the need for a light and user friendly use of 3D information: the data transfer capability of communication networks limits the usability of detailed models, given their large amounts of data; furthermore users need to have easy interfaces to interact with data.

3D models can be found on the internet just in simplified and light versions: VRML models or other specific solutions make it possible to navigate low scale object models, where the lack of geometric information is balanced by colouring with realistic radiometric information.

2.1 Google

When dealing with the delivery of spatial data, the best present solution is Google Maps, which has made spatial information available to everybody, managing where other web-GIS solutions didn't have the same success.

There are many reasons for this success, the main of which are:

- the ease of use which makes the application available to anyone who is able to use a PC and connect to the internet;
- the good application performance which makes it easy and enjoyable to use, and highlights Google's attention to data transfer;
- world wide data coverage which makes it possible to pass from product to service approach: before Google, the focus was on the product, the web-mapping tool, but since it has appeared, attention has moved to usage of tools;
- the easiness of developing a custom's developed application for web developer use;
- the choice of the internet as the communication infrastructure.

The same philosophy was followed by Google in the introduction of the third dimension in Google Earth: the more complex data made the use of client-side programs necessary; the more complex architecture makes it possible to interact with a low scale world elevation model in which users can add georeferenced and simplified 3D models of objects. The models can be downloaded in KML format and they can then be visualized.

This kind of approach can be useful for a general valorisation, for communication, or for low scale studies of objects, but in the cultural heritage field, it is not often possible to have heavy geometric simplifications without generating a completely new entity. Furthermore if a web access to 3D information is also for study or documentation purposes, detail and accuracy of 3D information is also necessary.

2.2 Solid image advantages

Solid image accomplishes some the Google's winning features:

- it offers a very simple interface which appears as a normal photographic image;
- 3D information storage is optimized for the specific photographic view, and is therefore light;
- the 3D model can be navigated, queried, but not downloaded, if does not need to be; this feature can be important as far as data ownership problems are concerned; furthermore users can extract the geometric information they need;
- the viewer architecture is simple, and there is no need for client application on the user side;
- the viewer is based on AJAX technology, which makes it possible to minimize the amount of transferred data.

Solid image therefore appears to be an interesting new opportunity for 3D fruition over the internet.

3. THE WEB VIEWER

3.1 The FOSS choice

The development of the *solid image* web-viewer has made it necessary to resolve different problems. It was first decided to base the application on already existing Open Source tools in order to have the chance of testing them, and choosing the most appropriate, with the support of a flexible and scalable architecture, and to speed-up the development process.

The alternative would have been the development of a completely new application but this would have involved longer times.

Furthermore, the use of proprietary software would have bound to a specific environment, without offering any particular advantages for the project purposes.

3.2 The FOSS used tools

The University of Minnesota MapServer was chosen as the graphical engine in order to visualize the digital images of the surveyed object;

Ka-Map was chosen as the development environment for the creation of the graphical user interface. This is an Open Source project which is aimed at providing a javascript API to develop highly interactive web-mapping interfaces using features available in modern web browsers.

Some of the most interesting features of ka-Map are:

- an interactive, continuous panning which works without the need of reloading the page;
- the chance of controlling the map navigation using the keyboard (zooming, panning);
- the chance of zooming to pre-set scales;
- scalebar, legend and keymap support.

The analysis phase highlighted two main key aspects: the way to visualize and explore a photographic image, and the way to store 3D pixel information in an appropriate database. Tools

from the GIS environment were used to approach the first one, whereas suitable data structure and system architecture were adopted in the second task.

3.3 The data structure

A benchmark was then started to evaluate different storage solutions for the 3D coordinates of the pixels.

Each solution meant a different software architecture, different application performances, and different algorithms to retrieve the 3D information of each pixel.

The benchmark proved the storing of the 3D information in a raster format to be the most appropriate one (Agosto, 2006).

3.4 Solid image viewer

During the benchmark testing, a prototype of the web viewer was realized, based on Mapserver and PHP scripting. The viewer was completely replanned, in order to offer a user-friendly fruition; the tool uses Ajax technologies in order to speed up the navigation of the *solid images*.

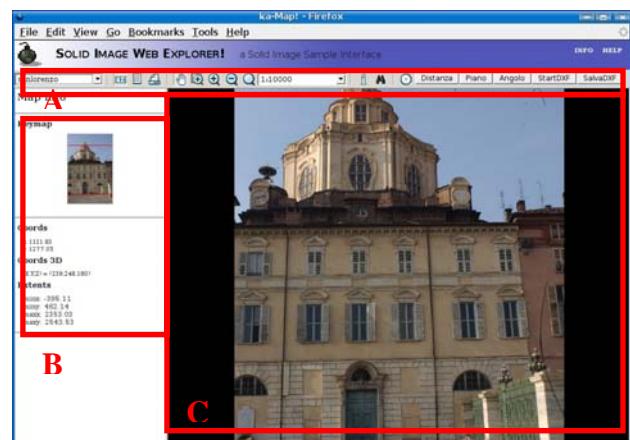


Figure 3. Solid Image Web Viewer structure: the toolbar (A), the info/layer section (B), the visualization area (C)

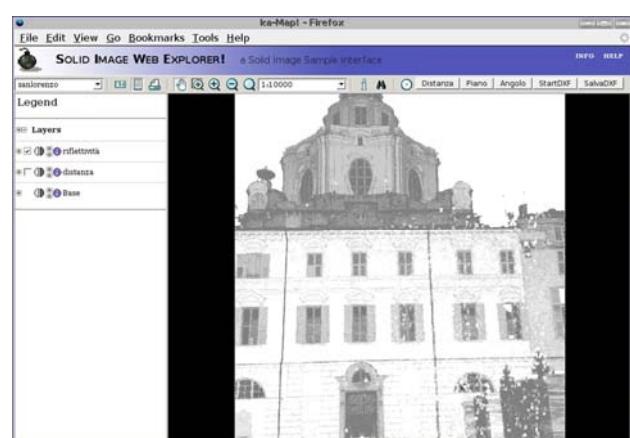


Figure 4. Solid Image Web Viewer: reflectivity information In the section B of Figure 3 available layers are now displayed

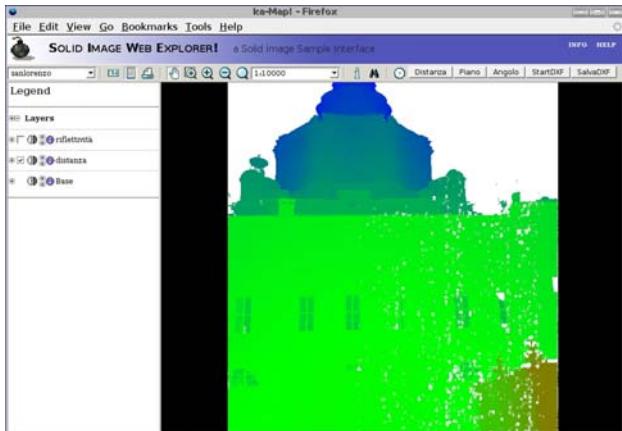


Figure 5. Solid Image Web Viewer:
information about the distance from the acquisition point

The use of the ka-Map interface environment improved the photographic image fruition: this tool in fact pre-generates different pre-set scale tiles of the image; the tiles are stored in a cache and they can then be used when necessary. In this way it optimizes the server work to create images which are then shown to the user.
The commands are also easier to use compared to the first rough viewer prototype ones.

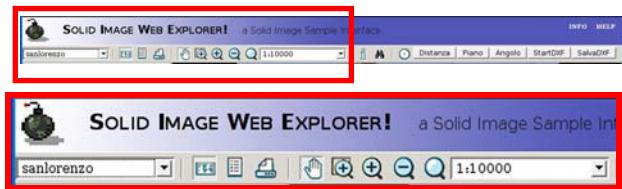


Figure 6. The toolbar. Part 1:
solid image choice, info/layer switch for part B of Figure 3,
navigation tools (from left to right)



Figure 7. The toolbar. Part 2: Analysis tools
Distance computation, equation of planes computation, angle
computation, start of DXF return of elements of interest, DXF
creation (from left to right).

The second step was to make it possible to access the 3D information connected to each pixel of the image; thus was obtained by customizing the ka-Map environment: the movement of the mouse generates an event that starts the query of the data, and ends up with the visualization of the coordinates in a specific part of the interface, without reloading the other parts that do not change.

This means the application has to respond quickly; as the digital image is a high resolution one, a continuous mouse movement generates a high number of server requests; an appropriate check was therefore introduced to prevent the server from

generating an increasing queue of unprocessed requests which would eventually lead to the server crashing.

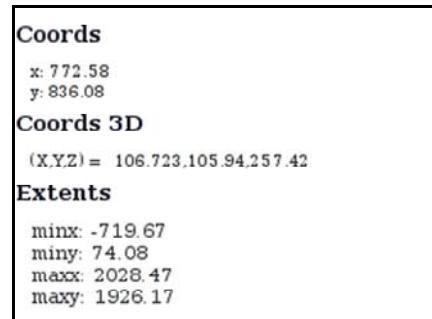


Figure 8. In the info section (B Figure 3) the X, Y, Z
coordinate of the pixel the mouse is over are continuously
updated

The second function which was developed through customization scripts in Php and JavaScript, was an instrument aimed to 3D distance measurement: the tool requires the collimation of two points on the image and returns the computation based on the 3D point coordinates. The selected points are highlighted by means of coloured points.

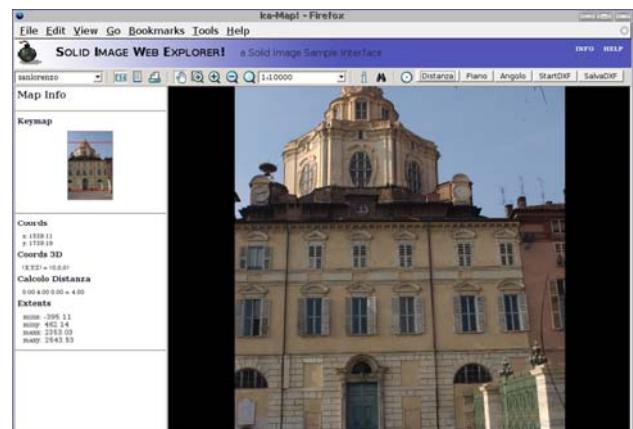


Figure 9. Distance measurement tool: after turning the tool on it
is possible to collimate points and have the result in the info
section



Figure 10. Distance measurement output in the info section (B
Figure 3). X, Y, Z and 3D distance in meters (from left to right)
The design of this tool and of the subsequent analysis ones was
based on AJAX technology, which makes it possible to avoid

the reloading of the whole page, while only updating the page with the computation results.

The other available analysis tools are the angle measurement tool and the plane measurement tool; the latter makes it possible to select a certain number of points and return the equation of the plane using a least square computation.

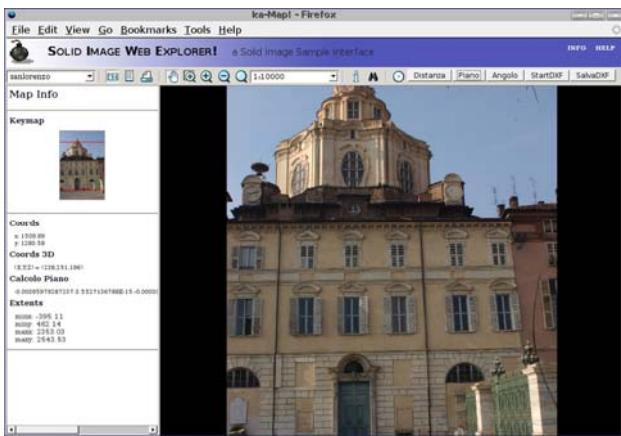


Figure 10. Plane measurement tool: equation plane is shown in the info section (B Figure 3); each point collimation after the third one, makes the equation to be re-computed.

The chance of having a DXF format output of a selected point was offered to the user, in this way he/she can have a on-line return of simple vector elements of interest. The application creates a temporary file on the server the user can download on his/her PC.

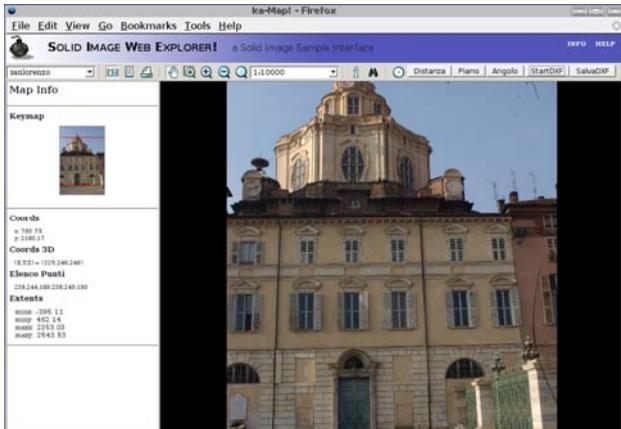


Figure 11. DXF export tool: the coordinates of the selected points are shown in the info section (B Figure 3)

The tool thus makes it possible for surveyors on the field to acquire the necessary data, and for geomatic experts to create then the *solid image*, and set up the web-fruition application, both in the field or in the office, with just the internet connection available.

Researchers who are not experts in the geomatic field can therefore directly return what is considered to be of interest, without the intermediation of a skilled operator or without leaving their offices, simply using their pc and a standard web-browser.

This tool could also be useful to create web-accessible archives for the documentation of objects.



Figure 11. DXF export tool: after the selection phase ends, the DXF is created in a web accessible location, and the link for its download appears in the info section.

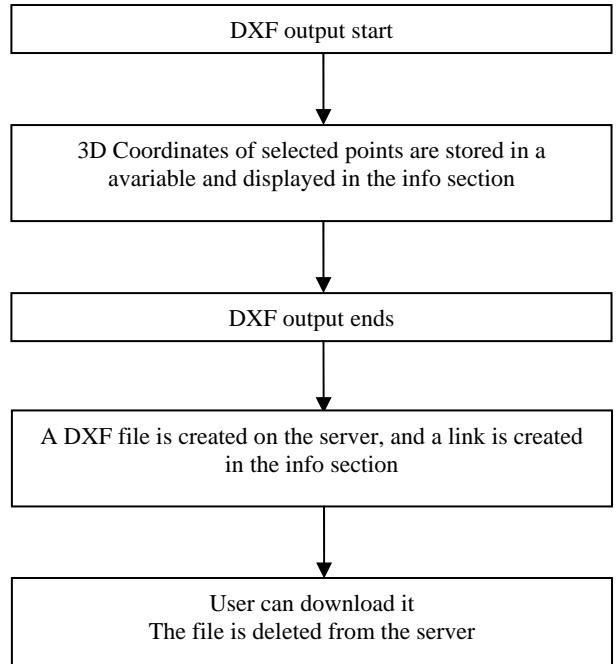


Figure 12. DXF export tool schema

3.5 The test site

The “S. Lorenzo” Church in Turin is considered one of the most famous Italian Baroque monuments. It was designed by the famous architect Guarino Guarini between 1668 and 1680. The façade is not that one of a typical religious building, as it has the appearance of an ordinary residential palace. With a central plant, the church is made up of by eight convex sides which are lit from above to that make it appear dynamic.



Figure 13. "S. Lorenzo" Church in Turin

4. CONCLUSIONS

Solid image is a promising tool for the presentation of 3D information; it offers an interesting and user friendly way of using LIDAR and photogrammetric data, even on a web infrastructure.

Its most interesting feature is the fact it is an accurate survey product which can be used by anybody as it is also possible to use it via web and it increases the number of people who can interpret a *Solid image* content. It is possible to consider scenarios where a survey campaign leads to a tool which could be analysed by different teams at the same time, each of which might have different study purposes. In the cultural heritage safeguard field, where there are often problems in obtaining concessions to start survey campaigns or in data ownership, it could represent a solution which would guarantee the ownership of data, as it is kept in a unique and safe place, but at the same time offering the possibility of carrying out an investigation by anyone who is interested.

Open Source tools make it possible to freely investigate the most appropriate solution for the *Solid Image* display on the web. These tools proved to be very flexible to integrate and use. UoM MapServer and its interface environment ka-Map in particular have proved to be capable of working outside a standard GIS environment they were designed for.

5. FUTURE EVOLUTIONS

A possible future development concerns the creation of an application that would make it possible to navigate the whole object and not simply a single portion of it, by offering the chance to navigate from one view and the related *solid image* to the next ones: in this way the available coloured 3D model could be used by mean of different views of the object and the connected *solid images*.

Furthermore, the overlay of vector elements should be improved, being at present quite rough. Vector elements are used to show user's collimations.

The DXF exporting tool, is at present thought for a single access user: a future step will be optimizing it in a way it can afford a multi client usage, making it possible for different users to create and download their own file at a time..

References

Bornaz L., Lingua A., Rinaudo F. (2002). *A new software for the automatic registration of 3D digital models acquired using laser scanner devices*. Proceeding of International Workshop CIPA on Scanning for Cultural Heritage Recording. Corfu.

Bornaz L., Dequal S. (2003). *The Solid Image: A new concept and its applications*. ISPRS. Commission V, WGV/4. Ancona.

Bornaz L., Rinaudo F., (2004). *Terrestrial laser scanner data processing*. XXth ISPRS Congress. Istanbul.

Agosto E., Ardissono P., Rinaudo F. (2005). *Survey methodologies for the preservation of cultural heritage sites*. The First International Symposium on Geo-information for Disaster Management (Gi4DM), Delft, The Netherlands.

Agosto E., Macera M., Rinaudo F. (2005). *A GIS for the monitoring of the hydraulic system of the Royal Racconigi Park*. CIPA XXth International Symposium, Torino,

Biasion A., Bornaz L., Rinaudo F. (2005). *Laser scanning applications on disaster management*. The First International Symposium on Geo-information for Disaster Management. Delft, The Netherlands

Agosto E., Bornaz L., Rinaudo F. (2006). *The visualization of the solid image on the web: a new tool for 3D information on the net based on an Open Source environment*. Goedatabase for sustainable development, ISPRS Commission IV Symposium, Goa, India.

References from websites

<http://httpd.apache.org>

<http://www.javascript.com>

<http://mapserver.gis.umn.edu>

<http://www.php.net>

<http://refractions.net>

<http://www.ominiverdi.org>

<http://ka-map.maptools.org>

Acknowledgements

The authors would like to thank the Open Source community for the chance it represents in the research field. In particular it is wanted to thank Mapserver and ka-Map developers.